Arrangement and Method for Remote Energy Supply of an Electronic Information Carrier

Description

This invention is related to an arrangement and a method for remote energy supply of an electronic information carrier by a base device according to the preamble of Claim 1.

There have been known methods and arrangements, in which an electronic information carrier containing electronic components for information processing, management or storage is supplied with energy from outside so that electrochemical energy stores, such as accumulators or batteries, in the information carrier may be dispensed with. EP 0536 430 A1 (H04B 10/00) describes a method for energy supply of a remote-control hand-held transmitter, e.g, for a motorcar locking system, in which the hand-held transmitter includes an energy store in the form of a capacitor. According to Claim 9, the recharging energy for the energy store may be transmitted in a non-contacting manner using ultrasound. Energy transmission is through the air from the car. In DE 4308372 A1 (E05B 47/00), there is shown a locking system remotely controllable by radio, light or ultrasound, in which the energy store of a portable transmitter is charged when the portable transmitter is located at least in the immediate vicinity of an energy dispenser arranged on the side of the lock. In that case, energy transmission is either inductive or by electric contact.

An arrangement for transmitting and/or receiving ultrasonic signals is shown in DE 9401489 U1 (H04B11/00). In that case, two ultrasonic modules are electrically coupled to each other through a supply lead.

In addition, other arrangements and methods form part of the state of the art, in which electronic energy stores are supplied with energy in a contacting manner through an electrically conductive connection, or in a non-contacting manner by optical as well as radio means, which has also been disclosed in the above-mentioned documents. In the so-called transponder technique, energy and information are also transmitted in a non-contacting manner using radio frequency waves. The advantage of all the arrangements and methods just mentioned is that the information carrier is maintenance-free in terms of energy store replacement, and that it is also possible to construct the information carrier so that it is simpler, more lightweight, more compact, and more enclosed, particularly in view of the capabilities offered by contemporary microelectronics and microsystems engineering.

In radio frequency transponders, in particular, energy transmission is very easy to implement. The documents mentioned above show a trend towards the non-contacting technique, as it has undisputed advantages in terms of handling comfort and flexibility.

Non-contacting methods, however, suffer under a number of safety and technical disadvantages. Any remote transmission of information through the air is subject to possible tapping by unauthorised persons, be it only to register the action as such.

In addition, with passive transponders there is a temporal and spatial uncertainty about the expression of will. In contrast, an unambiguous expression of will is manifest when actively operable information carriers and the contacting technique are employed.

Both optical and radio wave methods suffer from the drawback that only non-metallic materials are suitable as a "window" behind which an energy and/or information receiver is located. As metals permit electromagnetic waves to penetrate into the surface to a very limited extent only, the usual transponder, radio, and optical methods for the transmission of energy and/or information cannot be used where the information carrier is located behind metal or within a metallic and metal-rich body, respectively. On the other hand, ultrasound penetrates through all materials. A solution as described in EP 0536 430 A1, however, would also require the provision of a "window", either a hole or a thin membrane, in order to transmit both energy and information. In gases, sound absorption is very high, and sound energy is distributed quickly in all directions in space by reflection at solid bodies, so that it is no longer usable in a concentrated form. Therefore, a comparatively powerful acoustic energy source must be focussed and directed toward an article, if the information carrier, comprising an energy store to be charged, is located behind a thicker layer of material there.

As a result of the above disadvantages, the use of the mentioned methods is either difficult, related to major expenditure, or even impossible, if information carriers to be remotely supplied with energy are located within bodies, more particularly, within metallic bodies. Also, mounting them at

unobtrusive locations, which sometimes is necessary, is possible to a limited extent only. Either the material will have to be taken into account, or the information carrier and the transmitting/receiving unit thereof will be visible from outside, respectively.

It is known that acoustic waves propagate much better in condensed substances than in gases, which is why ultrasound may be used advantageously, e.g. for underwater locating purposes. Poor sound absorption of metals further permits such solutions as described in DE 92 10 894 (H04B 11/00), where a heating pipe system in buildings is used for transmitting information.

The object of the invention is to provide an arrangement and/or a method for remote energy supply of an electronic information carrier by a base device, which ensures that the information carrier may be placed both on the surface and in the interior a functional article, completely surrounded by metallic or non-metallic material, that low-energy solutions and an expression of will related to the transmission of energy and/or information are properly realisable, that there are good conditions for obtaining miniaturised embodiments of the information carrier, and that no electrically conductive connections are required to supply the information carrier with energy.

This object is solved with an arrangement and a method according to Claim 1.

The essential advantages of the invention all result from the fact that the entire arrangement according to Claim 1 forms a mechanically coupled and, therefore, acoustically very well coupled system, whereby the method according to Claim 1 becomes realisable. When the acoustic transmitting unit of the base device, constituting the acoustic energy source, and the functional article, i.e., the article housing the information carrier, contact each other at a point of contact, an energy sink will be present at such location through which acoustic energy then may flow into the functional article. This equally applies to the junction between the functional article and the information carrier, where there is the additional fact that the energy supply unit, preferably operating in the resonant range of the sound frequency, or also in a secondary excitation, forms a particularly powerful sink and immediately absorbs a very great amount of energy. Due to the resulting potential drop, a lot of acoustic energy will always continue to flow, no matter where the information carrier is located, because the sound has good penetration through the entire body of the functional article.

A major advantage is that the functional article is essentially unlimited by neither material nor shape thereof. Limitations imposed on the placement of the information carrier would be expected only with functional articles having a large quantity of gaseous inclusions or sound absorptions caused otherwise. This does not apply to the vast majority of metallic, ceramic, composite, and plastic, including rubber, articles employed in the industry or at home.

Even if there is a bodily contact to the surface of the functional article, this will constitute a remote energy supply, up to the information carrier. Using the arrangement and method

according to Claim 1, this will be feasible now even in those cases where the information carrier to be supplied is located behind thick layers of material, or is hidden anywhere inside a body. Positioning the information carrier at any location will require no particular effort, as line connections or other specific energy and information paths need not be taken into account. The only applicable condition is a good acoustic coupling, between the functional article and the acoustic energy source on the one hand, and between the information carrier and the functional article on the other, so that comparatively little primary acoustic energy can guarantee sufficient energy transmission. For that purpose, the information carrier preferably may be secured on or within the functional article by adhesive bonding, cementing, soldering, brazing, clamping, screwing or similar ways. For connecting the acoustic transmitting unit of the base device to the functional article, a surface-bodily contact will suffice, which contact, however, may be enhanced further by some force or the use of an acoustic coupling liquid. In contrast, non-contacting transmission through an air gap would require considerably higher sound energies, both for energy transmission to the information carrier and, in particular, for the information transmitting power of the information carrier. That would also be a serious obstacle to miniaturising the information carrier.

Moreover, making the contact will always constitute an unambiguous action, thereby very well satisfying the requirement for an expression of will as defined by the object of the invention.

Other advantages offered directly or potentially by the arrangement and method according to Claim 1 include possible ways of implementing a protection of the information carrier against the risk of destruction due to mechanical, chemical, electrostatic, radiation, thermal, or other influences.

Preferably, as energy receivers of the energy supply unit in the information carrier, transducers based on piezoelectric materials are suitable, while piezomagnetic, dynamo-electric or other suitable elements may be used in principle as well, as long as they transform the energy of acoustically induced mechanical vibrations directly or indirectly into electric energy. That equally applies to the information transmitting unit of the information carrier. In information receivers, other methods are also suitable, in which physical quantities, such as capacity or resistance and others, may form the basis of a sound or vibration sensor.

In some cases, it may be beneficial in practice for the information transmitting unit, the information receiving unit, and the energy receiving unit of the information carrier to form separate elements, thus making it possible for the respective individual task to be optimised in an entirely separate manner in terms of energy, dimensioning, functional principle, frequency, etc. This is true for both the transducer and the upstream and downstream electronics, respectively. In other cases, a joint use of various components may be preferred for other reasons. In particular, though not necessarily, this may be the aim where the general focus is on miniaturising the information carrier. According to Claim 2, that will be possible, including a complete

merger to form a single unit. Then, energy and information will be received through a common transducer, to be separated by a downstream electronics. Conversely, this transducer serves to transmit information.

Mounting all components of the information carrier on a common base, e.g. on a ceramic, plastic or film-type printed-circuit board, as can be implemented according to Claim 3, is favourable for various reasons, such as handling, assembly or miniaturisation. In particular, if the intention is to miniaturise the information carrier, the arrangement and method according to Claim 1 will offer best alternatives for implementation in the field of microsystems engineering according to Claim 4. As an effective transmission of both energy and information can be effected through the bodily-acoustic contact path according to Claim 1, it is possible to work with very small total energies. This implies the major advantage that all the components of the information carrier, from the transducer to capacitors as intermediate energy stores, to any electronic semiconductor components required, can be designed with very small space requirements. It is only by this approach that microsystems engineering dimensions can be accomplished, that permit accommodating all the information carrier components in an area of just a few mm^2 or smaller. Semiconductor technologies used for microsystems engineering, especially silicon engineering, and microassembly engineering may be used favourably for manufacturing a subminiature information carrier to be used within the arrangement and according to the method of Claim 1.

For practical handling purposes and other reasons mentioned below, it will be useful to have the information carrier available in a compact form, e.g., in a plastic-embedded body according to Claim 5, or in the form of a capsule according to Claim 6. Then, such an information carrier could be accommodated conveniently within any bodies, i.e. the functional articles.

If necessary, it may be helpful to have another way of information transmission available in addition to the acoustic path, e.g., to transfer information to certain memory areas which cannot be erased later, prior to placement into the functional article. This will be possible by providing at least two metallic points of contact on the outside according to Claim 7, which are connected in an electrically conductive manner to electronic components of the information carrier.

The opportunities for developing information systems provided by Claim 1 are of extraordinary variety and cannot be attained by any other information system. The main reasons for restrictions in other systems are that the information carrier may not be placed into any article whatsoever, and at any "depth", that partly a considerable amount of energy has to be used on at least one side of communication, and that energy maintenance is required, such as checking and replacing batteries. A system based on Claim 1 would solve the placement problem on the one hand, and would permit at least low-energy solutions to the overall system on the other. Basically, the solution demanding the least energy is direct electric contact. This will be possible according to Claim 8 where the two metallic parts mounted on the functional article provide another way of

accessing the information carrier, if required. That will be a particular benefit in a functional article having multiple functions, such as a key according to Claim 11, if a specific lock does not include an acoustic, but only an electric information transmitting unit.

Advantageously, the metallic element according to Claim 9 may also be employed for energy saving purposes, as it can be used in a simple manner to trigger an action; for example, switching the acoustic transmitting unit of the base device on, either with a time limit or during the hold time at the contacts.

Because a system based on the arrangement and method according to Claim 1 offers a widest possible placement range for the information carriers according to Claims 1-9 compatible therewith, a large number of articles may be fitted with information carriers, preferably those based on Claims 5 and 6, at a very early stage of manufacture. Thus, according to Claim 10, it would be possible to file, read or re-write product-relevant information about the entire product life, starting from manufacture, for purposes of production, distribution, sales, servicing up to recycling, so that it will be "deeply hidden inside the product" and protected against destructive access in a very safe manner. In doing so, a chip-internal safety system may easily implement a selective read/write protection mechanism.

Another interesting opportunity arises when the arrangement and method according to Claim 1 form the basis of a locking system. Apart from conventional keys and key-ring pendants, according to Claim 11, the function of a key could be transferred

easily and inconspicuously to any other article without the function thereof being recognisable from outside. Any every-day item, such as writing implements, watches, buttons, glasses, etc., would be suitable.

Specific advantages result, if pieces of jewellery according to Claim 12 and, more particularly, rings form the functional articles. These are worn closely to the body so that the risk of losing them is very small. Similarly, cards according to Claim 13, especially those having a chip card format, could be used favourably as functional articles.

The use of the arrangement and method according to Claim 1 in the automotive sector according to Claim 14 should also receive a special mention. Apart from the advantages for product description mentioned above, this would provide especially favourable benefits for the production, marketing, and service system as a whole, and for preventing and combating crime. In such a case, it would not only be the car as a general product, but also various components that could individually be provided with corresponding information carriers, which are also used in mutual communication, if necessary, through corresponding relay stations according to Claim 15, in order to fulfil additional safeguarding tasks, e.g., starting the engine only if certain or all of the information carriers are present. The combination with a ring for a finger forming the functional article offers another variant for safeguarding and operating the car in a particularly safe and elegant way.

The relay stations of Claim 15 operate as repeaters for the communicating information carriers in the various functional articles as regards information transmission, and/or they assume the energy supply function, if required. Thus, they constitute a special form of a base device.

The present invention will be explained below in greater detail with reference to an embodiment thereof.

In the drawings:

Fig. 1 shows a sketch for explaining the fundamental principle;

Fig. 2 shows a multifunctional arrangement of various base devices including a ring for a finger forming a functional article;

Fig. 3 shows an arrangement including a piece of jewellery as a functional article used for identification purposes;

Fig. 4 shows an arrangement including a card having the standard chip card format as a functional article; and

Fig. 5 shows a partial arrangement including a bicycle as a functional article used for the identification thereof.

Referring to Fig. 1, there is shown a base device 1 connected through a cable 2 to the acoustic transmitting unit 3 designed as a hand-held device. The acoustic transmitting unit 3 can not only produce the acoustic energy in the form of ultrasound, but is also capable of transmitting and receiving acoustic information in this case. When the functional article 4,

which forms a steel block and is provided as starting material for fabricating a special gearbox member, is contacted by the acoustic transmitting unit 3, acoustic waves penetrate into the functional article 4 to reach the information carrier 5 on a bodily path. The information carrier 5 is adhesively bonded into the end of a hole 6 inside the functional article 4, thereby protecting it against any accidentally destructive access during subsequent turning and milling operations. In Fig. 1, the information carrier 5 is shown again on an enlarged scale to consist of a cylindrical steel capsule 7 of 4 mm diameter, housing on a silicon chip 8 the electronic information processing unit 9, i.e., a microcontroller, an energy supply unit 10, an information receiving unit 11, and an information transmitting unit 12, each consisting of a piezoelectric transducer 13, 14, 15 and a downstream electronics 16, 17 processing the electricity generated by the piezoelectric transducers 13, 14 for use in the information carrier, and an upstream electronics 18 supplying the piezoelectric transducer 15 with the information to be transmitted in the form of electric signals, respectively. Isolation of the individual piezoelectric transducers 13, 14, 15 and the electronics 16, 17, 18 associated therewith is possible due to the high obtainable degree of miniaturisation in semiconductor technology, and permits separate reception of energy and information as well as independent transmission of information. On the rear side thereof, the silicon chip 8 has been fixedly secured to the capsule 7 using an adhesive.

With the arrangement shown in Fig. 1, the operator of a machine tool may obtain essential fabrication data for the gearbox member from the information carrier 5 to supply it to the

machine tool, and feed information on the result of his or her work into the information carrier 5.

In Fig. 2, there is shown a functional article 4 configured as a ring for a finger, the acoustic transmitting unit 3 configured as a plate provided for a car door, and a receiving unit in the form of a disk 30 to be attached to a letter box. The ring holds the information carrier 5 within a recess 19. A flexible base 20 mounts all the elements of the information carrier 5 thereon. On its exterior, it includes two metallic points of contact 21, which in turn are connected to the two metallic parts 22, shown to be formed by the ring itself and a ring element mounted in isolation from the ring. After bonding the information carrier 5 in place, the recess 19 has been closed by a lid 23. The piezoelectric transducer 24 is covered by a cap 25 to prevent the mechanically vibrating parts thereof from being impaired in their functions. Together with the electronics 26, it forms a unit 27 assuming the combined functions of the energy supply unit 10, information receiving unit 11 and information transmitting unit 12 in that case.

On the transmitting unit 3 in the form of the plate, there are provided two contacts 28 to be bridged when touched by the ring. Acting as a metallic element 31, the ring itself causes the bridging to occur. Thus, it will activate the transmitting unit 3, and the exchange of information will take place with the information carrier 5 inside the ring through the contacting acoustic path. The above-mentioned letter box does not constitute a base device 1. It only includes an electronic lock operated by the two contacts 29 which are used for transmitting both energy

and information. Thus, the lock of the letter box may be opened if the two metallic parts 22 are engaged by the contacts 29.

The application of the present invention to the identification of jewellery is illustrated in Fig. 3. As shown, the base device 1 forms a reading and programming device including a display screen 32, and is connected through a cable 2 to the acoustic transmitting unit 3, in which a piezoelectric transducer 33 is mounted below a supporting steel plate. Onto that supporting plate, the functional article 4 shown in Fig. 3 as having the form of a ring for a finger, but which may also be a brooch, watch, bracelet or other piece of jewellery, may be placed or pressed. Inside the functional article 4, there is located a cavity 34. The information carrier 5 may be inserted through a hole into the cavity 34, and secured with adhesive 35. On completion of such assembly work, the hole may be closed by a closure 36 made of the same material as the functional article 4. Apart from adhesive bonding, brazing and welding are also possible techniques for assembling, during which the mounting site of the information carrier 5 will have to be cooled, if necessary. After the closure 36 has been welded to the ring forming the functional article 4, and after the surface has been correspondingly re-worked, it will be impossible to recognise from the outside that an information carrier 5 is mounted within the ring. To ensure communication, the information carrier 5 need not necessarily confront the piezoelectric transducer 33 directly as shown in Fig. 3, although the shortest distance is generally favourable. Because the information carrier 5 is completely surrounded by metal within the functional article 4, any destruction of the electronics of the information carrier 5 by possible external electrostatic fields or charging actions will

be virtually excluded. That equally applies to the application shown in Fig. 4 where the functional article 4 has the form of a chip card, which in this case consists completely of metal. Use of special steel or titanium alloys may be preferred. Chip cards of that kind may be designed in a more rugged way compared to known plastic chip cards in terms of mechanical strength, environmental durability and protection against electrostatic hazards. Handling, too, is extremely easy by placing it onto the corresponding acoustic transmitting unit 5 which corresponds to the read/write interface or reader for known chip cards.

Another very practical usage is pointed out in Fig. 5. Placing the information carrier in a bicycle forming the functional article 4, e.g., in the frame member 37, will be a very simple and unobtrusive way of identifying bicycles. By means of a plug 38, removal of such an identification may be prevented or made so difficult that it can be accomplished only by destroying the bicycle forming the functional article 4, which is not in the interest of bicycle thieves either.

In summary, the embodiment shown in Figs. 1-5 illustrates that any articles may be transformed into functional articles 4, by mounting in the interior thereof an information carrier 5 enabling an exchange of both energy and information to take place through acoustic waves, and having an internal structure exemplified by Figs. 1 and 2. For that purpose, miniaturisation of the information carrier 5 is an important condition, so as to be able to equip even small articles in that way, impair as little as possible the external appearance of the articles along with the properties and applications thereof, and not to restrict their mobility. As a result of the present invention, articles become capable of communicating. In the invention, mono- or bi-

directional communication typically is initiated and maintained during the surface contact between the acoustic transmitting unit 3 of a base device 1 and the articles. Establishing the contact, which in general will be made only during the energy and information transmission, can be carried out by manual or mechanical movement of the acoustic transmitting unit 3 toward the functional article 4, or vice versa. The information underlying the communication may be entered from outside using the acoustic transmitting unit 3 of a base device 1, as is shown in Figs. 1-5, and it may be supplied independently thereof from sources internal to the article, e.g., from measuring points, to the information carrier 5. This may be performed by acoustic or other means, such as electric lines.

List of reference numbers

1 base device

2 cable

3 acoustic transmitting unit

4 functional article

5 information carrier

6 hole

7 capsule

8 silicon chip

9 electronic information processing unit

10 energy supply unit

11 information receiving unit

12 information transmitting unit

13 piezoelectric transducer

14 piezoelectric transducer

15 piezoelectric transducer

16 downstream electronics

17 downstream electronics

18 upstream electronics

19 recess

20 flexible base

21 metallic point of contact

22 metallic parts

23 lid

24 piezoelectric transducer

25 cap

26 electronics

27 unit

28 contacts

29 contacts

30 disk

31 metallic element

32 display screen

33 piezoelectric transducer

34 cavity

35 adhesive

36 closure

37 frame member of functional article

38 plug